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(54) ELECTRON GUN AND ITS METHOD OF USE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an electron gun capable of working at high angular current density suitable for use such as in an electronic photolithography device.
SOLUTION: The electron consists of an electron emission cathode, a control electrode and an extraction electrode, of which the electron emission cathode is composed of rare earth hexaboride compound and the tip of the electron emission cathode activate the electron gun arranged between the control electrode and the extraction electrode under temperature limit area.

CLAIMS

[Claim(s)]
[Claim 1]An electron gun, wherein it is an electron gun which consists of electron emission cathode, a control electrode, and an extraction electrode, electron emission cathode consists of a rare earth 6 way ghost and a tip of this electron emission cathode is moreover arranged between a control electrode and an extraction electrode.
[Claim 2]The electron gun according to claim 1, wherein a tip of electron emission cathode is sphere form.
[Claim 3]The electron gun according to claim 1 having a flat face at a tip of electron emission cathode.
[Claim 4]The directions for an electron gun which is the directions for an electron gun of claim 1, claim 2, or claim 3, and is characterized by operating electron emission cathode under a temperature limitation field.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to electron guns, such as an electron microscope, an Auger-electron-spectroscopy device, an electron-beam-lithography machine, an electron beam tester, and wafer test equipment, and the electron gun especially for electron-beam-lithography machines.
[0002]
[Description of the Prior Art]In recent years, rather than the electron beam acquired by hot cathode, in order to acquire a long lasting higher-intensity electron beam, the electron gun using the negative pole which provided the enveloping layer of a zirconium and oxygen is used for the needlelike electrode of the tungsten single crystal (it is hereafter described as a ZrO/W electron gun).
[0003]In length measurement SEM and wafer test equipment which are used with low acceleration voltage, the ZrO/W electron gun has stable probe current, and is used abundantly for the reason a spread of energy width is suppressed, and operates with the angle current density of 0.1-0.2mA/steradian in this case.
[0004]In the electron beam tester, an electron-beam-lithography device, the Auger spectral device, etc., since a throughput is thought as important, are operating with the high angle current density of about 0.4mA/steradian, but. in the use which thinks such a throughput as important, still higher angle current density operation is desired -- a 1.0mA [/steradian] thing -- operation with high angle current density may be required.
[0005]
[Problem(s) to be Solved by the Invention]However, in a ZrO/W electron gun, (1) It is a maximum at most in about 1.0mA/steradian as angle-of-elevation current density operation, (2) When making it operate by 1.0 mA/about steradian, the drawer voltage impressed between the

negative pole and an extraction electrode is as large as not less than 4 kV, The field intensity in the tip of a needlelike electrode becomes remarkably high with 0.4 - 1.0x10 ^{9}V/m (J. p220"Emission Characteristics ofthe). [Vac.Sci.Technol.B.3(1) 1985,] There is a fault of the trouble frequency by ZrO/W Thermal Field Electron Sources" reference and arc discharge becoming high and needing the ultrahigh vacuum below (3)1x10 $^{-6}$Pa further.

[0006]When this invention person considers electron emission cathode which consists of a rare earth 6 way ghost as specific structure arrangement as a result of examining many things in light of the above-mentioned circumstances, he makes the tip of said electron emission cathode specific shape and makes it operate under a temperature limitation field, It finds out that said technical problem can be solved at once, and results in this invention.

[0007]

[Means for Solving the Problem]That is, this invention is an electron gun which consists of electron emission cathode, a control electrode, and an extraction electrode, and is an electron gun, wherein this electron emission cathode consists of a rare earth 6 way ghost and the tip is moreover arranged between a control electrode and an extraction electrode. It is the aforementioned electron gun a tip of electron emission cathode being sphere form, or having a flat face as a desirable embodiment of this invention.

[0008]In addition, this invention is the directions for said electron gun, and is the directions for an electron gun operating electron emission cathode under a temperature limitation field.

[0009]

[Embodiment of the Invention]This invention is explained based on illustration of drawing 1. The tip of the electron emission cathode 1 which consists of a rare earth 6 way ghost is arranged between the control electrode 6 and the extraction electrode 7 as the electron gun of this invention was illustrated to drawing 1. In this invention, although the polycrystalline substance of the rare earth 6 way ghost may be sufficient as the electron emission cathode 1, since the electron beam acquired is stable, consisting of single crystals is preferred. In the case of a single crystal, as an electron emission side, it is a low work function side and the field where a symmetrical electron beam is acquired (100) is preferred.

[0010]In the electron gun of this invention, an electron beam is emitted from the electron emission cathode 1 by impressing negative high tension to the electron emission cathode 1 to the extraction electrode 7. The control electrode 6 interrupts the thermal electron emission from the side of electron emission cathode, and further negative voltage is usually impressed to the electron emission cathode 1.

[0011]By using said composition for the electron gun of this invention, and operating said electron emission cathode 1 under a temperature limitation field, Have the feature which can obtain desired angle current density according to the tip part shape of the electron emission cathode 1, and further, if it depends on this invention person's examining result, It is possible

to attain the far-reaching angle current density of 0.2-70mA/steradian, and since electron emission cathode moreover consists of a rare earth 6 way ghost, the vacuum of operation also has the feature that a $1x10^{-5}$Pa grade may be sufficient.

[0012]In this invention, although the shape of the tip part of said electron emission cathode is chosen by the angle current density etc. for which it asks, the thing whose tip is sphere form, or the thing which has a flat face at a tip is chosen. What is necessary is for the former to have the feature which what has the high angle current density in early stages of operation tends to acquire, and just to choose according to a use, respectively, since the latter has the feature which the angle current density stable over the long period of time tends to acquire. What is necessary is just to apply the publicly known machining method, electrolytic polishing, etc. conventionally, in order to control the shape at the tip of electron emission cathode.

[0013]Although it has a heater which heats electron emission cathode, it is preferred to consider it as the arranged heater block 2 made from carbon so that electron emission cathode may be pinched as the electron gun of this invention was shown, for example in drawing 1. it is because it is an appropriate substance which is alike and as for which carbon cannot react to the rare earth 6 way ghost easily. As said said heater block made from carbon, pyrolytic carbon (or pyrolytic graphite) is preferably adopted in consideration of thermal conductivity or electrical resistance.

[0014]It is common to grasp the heater block 2 which grasped the electron emission cathode 1 in the method of pinching electron emission cathode with the aforementioned heater block to the insulating insulator 4 with the grasping tools 3 located in the other end of the conducting terminals 5 by which low attachment was carried out. If current is sent through the conducting terminals 5, the heater block 2 will generate heat with Joule heat, and the electron emission cathode 1 will be heated.

[0015]the temperature (only henceforth negative electrode temperature) of the electron emission cathode of the electron gun of this invention -- 900-1900K -- it can operate in 1500-1700K preferably. According to this invention, by obtaining about 5mA/steradian angle-of-elevation current density on the drawer voltage below 1 kV with the negative electrode temperature of 1700K, and choosing the curvature radius at the tip of the negative pole or the diameter of a flat face under a temperature limitation field can prescribe operating angle current density. When tip curvature is 5 micrometers, the field intensity in the tip of electron emission cathode in case drawer voltage is 1 kV is abbreviation $5x10^{7}$V/m, and the occurrence frequency of arc damage can make it low to Haruka lower [whether you are Haruka] than a ZrO/W electron gun therefore.

[0016]

[Example][Examples 1-6] an insulation -- an insulator -- four -- a low -- attachment -- carrying out -- having had -- a couple -- conducting terminals -- five -- the other end -- providing --

having had -- grasping tools -- three -- < -- 100 -- > -- a direction -- six -- Howe ---izing -- a lantern -- from -- becoming -- electron emission cathode -- one -- a couple -- pyrolytic carbon -- make -- a block heater -- two -- putting -- grasping -- electron emission -- cathode structure -- having carried out . The tip of the electron emission cathode 1 which consists of a 6 Howe-ized lantern has a 60-degree cone angle, and created several kinds of what has a circular flat face (examples 1-3), and things (examples 4-6) which carried out shape of sphere form.

[0017]Electron emission cathode structure was included in the device shown in drawing 2, it has arranged so that the electron emission cathode 1 may be located between the control electrode 6 and the extraction electrode 7, and it was considered as the electron gun. The block heater 2 made from pyrolytic carbon is connected to the heating power 8, and also it is connected to the high voltage power supply 11, and is impressed to the extraction electrode 7, negative high tension Vex, i.e., drawer voltage. The control electrode 6 is connected to the bias power supply 9, and further negative voltage and the bias voltage Vb are impressed to the electron emission cathode 1. The total radiation current It from the electron emission cathode 1 is measured by the ammeter 11 placed between the high voltage power supply 10 and the ground. The electron beam 16 emitted from the tip of the electron emission cathode 1 passes the hole of the extraction electrode 7, and reaches the shield 12. The probe current Ip which there was the aperture 14 (stoma) in the center of the shield 12, and passed and reached the cup shape electrode 13 is measured by the microammeter 15.

[0018]If the solid angle computed from the distance at the aperture 14 and the tip of the electron emission cathode 1 and the inside diameter of the aperture 1 is set to omega, angle current density will serve as Ip/omega. As for the distance of 0.15 mm, the control electrode 6, and the extraction electrode 7, the aperture of 0.8 mm and the control electrode 6 of the aperture of 0.8 mm and the extraction electrode 7 is [the tip of the electron emission cathode 1, and distance of the control electrode 6] 0.8 mm.

[0019]Using said characterization device, energizing heating was carried out to the block heater 2 made from pyrolytic carbon under the vacuum of $1x10^{-5}$Pa, and temperature of the electron emission cathode 1 was set to 1700K. The temperature of the electron emission cathode 1 was measured with the radiation thermometer. Next, it pulled out having impressed the bias voltage Vb -300V and monitoring angle current density, the voltage Vex was changed, and electron emission characteristics were compared. The measurement result was shown in drawing 3.

[0020]With the increase in drawer voltage, angle current density increased rapidly and showed the peak value of not less than 5mA/steradian. When drawer voltage was increased, it has checked that angle current density fluctuated according to temperature, and it was in a temperature limitation field when it stops being dependent on drawer voltage and angle current density changes the temperature of the electron emission cathode 1 to a trial. In this field, if the

temperature of the electron emission cathode 1 is constant, it will depend for operating angle current density on the tip shape of the electron emission cathode 1. In the electron gun obtained in Examples 1-6, it pulls out with the tip shape of the electron emission cathode 1, and angle current density in case the voltage Vex is 1 kV is shown in Table 1.

[0021]

[Table 1]

	チップの先端形状	チップ先端の寸法	引き出し電圧が1kV時の角電流密度 (mA/sr)
実施例	円形平面	20μmφ	1.1
2	円形平面	50μmφ	4.7
3	円形平面	100μmφ	12
4	球面	5μmR	0.23
5	球面	10μmR	0.29
6	球面	100μmR	60

[0022][Comparative example] When commercial ZrO/W electron emission cathode was attached to the same device, evaluation of electron emission characteristics was tried under the ultrahigh vacuum of 1×10^{-7} Pa for comparison and angle current density exceeded steradian in 1mA /, it was able to be damaged by arc discharge and was not able to be made to work stably.

[0023]

[Effect of the Invention]The wide range angle current density of 0.2-70mA/steradian is obtained, and the electron gun of this invention has without failure by arc discharge the feature which can control operating angle current density by moreover choosing the shape at the tip of the negative pole.

[0024]Since the electron gun of this invention has said feature, it is suitable for the use which needs the angle current density of 1mA/steradian or more which could not be conventionally attained with a publicly known ZrO/W electron gun, and dramatically useful industrially.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The lineblock diagram which illustrates the electron gun of this invention.
[Drawing 2]The lineblock diagram of the evaluation system of electron emission characteristics.
[Drawing 3]The figure in the electron gun of this invention in which pulling out with angle current density and showing the relation of voltage.
[Description of Notations]
1: Electron emission cathode
2: The heater block made from pyrolytic carbon
3: Grasping tools
4: Insulating insulator
5: Conducting terminals
6: Control electrode
7: Extraction electrode
8: Heating power
9: Bias power supply
10: High voltage power supply
11: The ammeter for total radiation current measurement
12: Shield electrode
13: Cup shape electrode
14: Aperture
15: The microammeter for probe current measurement
16: Radiation electron beam

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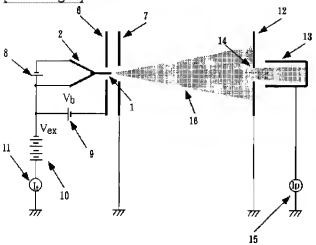
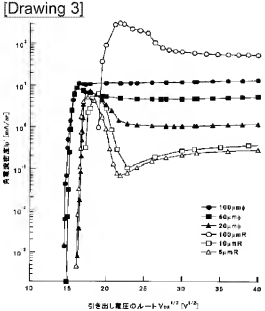
DRAWINGS

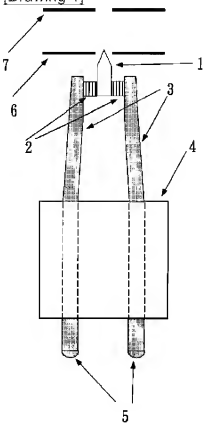
[Drawing 2]



[Drawing 3]



[Drawing 1]



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